

Plate 1: Distribution and Sources of Geologic Data, and Plates 2A-C: Geologic Cross Sections—Expanded Explanation, City of Alexandria and Vicinity

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Introduction

Geologic data from a variety of sources were utilized to construct the geologic maps of Alexandria. The sources of data can be broadly grouped into two types: surface exposures and subsurface data. Numerous observations were made at surface exposures, which include natural outcrops, various types of excavations, and other disturbed areas where soil, sediment, or bedrock are exposed. Most of the large natural outcrops in the city are found in the valleys of modern streams, though some exposures also can be found on steep bluffs in the uplands. Several major excavations for large buildings and numerous minor ones for utility trenches, roads, foundations, gravel pits, and other infrastructure were also available for examination on an opportunistic basis during the course of this study and yielded valuable geologic information. In many places, landforms and the vegetation communities growing on them also gave important insights into the underlying geology, especially in parks, natural areas, and other places where historical disturbance of the soil is minimal. These traditional sources of geological information were augmented by subsurface data from hundreds of sites, consisting chiefly of old water wells catalogued by previous investigators, and more recent geotechnical (engineering) borings made for roads and buildings, and collected specifically for this project. As outlined below, the sources of the subsurface data are varied, with highly disparate formats that range from rudimentary summaries of well construction data in 50-year-old maps and tables (e.g., Johnston, 1961; Darton, 1950), to electronic, GIS-based borehole databases for specific large projects (e.g., VDOT's reconstruction of the Capital Beltway from Woodrow Wilson Bridge to Telegraph Road). Because no two data sources are alike, an attempt was made to synthesize the key geologic aspects of all the data into a series of three MS-Excel databases in order to a) facilitate ease of use and comparability; b) provide a means by which individual data or geologic cross sections can be electronically linked to the geologic maps at such time in the future as the maps are put into the city's GIS; and 3) ensure repeatability, consistency, and availability to future investigators by providing a secure, compact, and complete data archive. Each location of a surface exposure or subsurface data set is tagged with a unique master ID number to enable unambiguous identification of the source and to facilitate future reconstruction of data points.

Description of Data by Source

Surface Exposures: More than 250 numbered surface exposures in and near the city were visited in the course of this project. Each locality is shown on plate 1 and summarized in the accompanying database entitled "Alexandria Exposures". Each exposure is marked by two identifiers: the unique master ID number mentioned above, and a "field number" that was generated during the fieldwork portion of the study. In about half the cases, the two identifiers are the same, and simply represent the order in which exposures at various random locations throughout the city were visited during the project. They differ in the case of large parks or similar tracts, where the field number incorporates a prefix to identify the tract, e.g., DK-1, DK-2, etc. identify exposures 1, 2, etc. in Dora Kelley Park; likewise, CP-21 and CP-22 are exposures 21 and 22 in Chinquapin Park. Master ID numbers 1-500 were reserved for surface exposures; there currently are 254 of such numbered exposures. In addition to the ID numbers, the database also gives the location (by UTM and physical description), altitude, date visited,

geologic unit(s) present, and a brief description of the geologic features at each site. The nature of the exposure (size, natural outcrop vs excavation, etc) is clearly explained in the database; through the use of different symbols and patterns, plate 1 also visually differentiates natural outcrops, excavations, and sites where the landscape or landform is the primary feature of geologic interest. Exposures shown on plate 1 are identified by their master ID numbers. It should be noted that outcrops may change or become obscured through time, especially in an urban setting. Natural processes like weathering, sedimentation, and slumping can obliterate outcrops over periods ranging from months to years to decades, depending on the scale of the exposure. Likewise, excavations are, by definition, temporary exposures, hence it is important that the geologic information they reveal be archived in a permanent way. Finally, there are numerous forces uniquely associated with the urban environment that can either degrade exposures or produce new ones: site grading, road widening, establishment of vegetation, building construction, and excessive pedestrian traffic in sensitive areas are just a few examples of numerous changes in land use commonly found in an urban setting.

Subsurface Data-Water Wells: The subsurface data compiled for this project can be broadly divided into two categories: water well construction data, and geotechnical engineering borings. Water well data were obtained from three main sources, all from the US Geological Survey (USGS, see references), hence they are catalogued in the Excel database entitled “Alexandria USGS Wells”, which contains three pages of data, each corresponding to one of the three sources described below. Like the surface exposures, each well location was tagged with a unique master ID number. Master numbers 501-800 were reserved for water wells; there are currently 209 such wells in the database (#’s 501-709). On plate 1, wells are identified by a consecutive, second order ID number (e.g., 1, 2, 3, etc) within each particular source. It is important to note that some of the wells in the database lie outside of the map area in somewhat more distant parts of Fairfax and Arlington Counties. These more distant wells were useful for interpreting the regional topography of the bedrock surface, and their locations were plotted on a smaller-scale (1:24,000) work map, but do not appear on the plate.

Johnston (1961, 1964): Johnston systematically documented the locations and characteristics of thousands of water wells throughout the greater Washington area, hence, this is one of the single largest and historically important sets of subsurface data available. He presents data on some 150 wells in and adjacent to Alexandria, some of them being deep industrial or public supply wells. The vast majority of the wells no longer exist, hence, the maps and tables compiled by Johnston represent a valuable, archival data set. Of the wells documented by Johnston in the study area, 6 include actual formation logs describing in detail the geologic strata encountered during well construction. The rest of the entries are summarized by total depth, casing length, aquifer the well was finished in, static water level, and other features that can be useful for geological interpretation. The principal uses of this data set in the present project were for determining the depth to bedrock and ascertaining water levels in selected aquifers; the 6 formation logs were also invaluable for interpreting the lithofacies relations of the Potomac Formation. Johnston (1964) devised a well-numbering scheme in which each 7.5-minute topographic quadrangle was divided into 9 roughly equal rectangles by drawing north-south and east-west lines through each 2 ½-minute tic mark on the quadrangle, and then numbering the wells consecutively within each rectangle. This system was retained for this project and constitutes the “field number” of each well shown in the database and on plate 1. For example, AX-AA-1 refers to well #1 in rectangle AA of the Alexandria (AX) topographic quadrangle.

The published water-supply report (Johnston, 1964) depicts the locations of the wells on a 1:62,500 map, but otherwise contains no systematic descriptions of individual wells. Such descriptions are found in a set of typewritten tables that form the bulk of an obscure open-file report (Johnston, 1961) that is not readily accessible because of both its format and because it initially did not appear in the USGS library catalogue, and was finally located in an obscure location in the basement of that library. As a result, all of the water-well data contained in the tables pertaining to Alexandria and nearby areas were recreated electronically in the page called “Johnston 1961” in the “Alexandria USGS Wells” database, and their locations are identified on plate 1.

Froelich (1985): This report focuses chiefly on Fairfax County and consists exclusively of a series of small scale (1:100,000) maps highlighting various features of the Potomac Formation, as interpreted from surface and borehole data. Wells and boreholes are represented by a series of dots on the maps, of which about 50 are in or near the city. The maps were compiled from a series of open file reports—generated during the USGS Fairfax County mapping program of the 1970’s—that present the same data at a scale of 1:24,000; however, only a portion of these reports are still available. Therefore, the locations of some of Froelich’s data points had to be interpolated from small-scale base maps that show very few geographic features to which the locations could be referenced. Nonetheless, this data set was very useful for both interpreting the elevation of the bedrock surface and for reconstructing the lithofacies of the Potomac Formation. No basic descriptions of the data points (sources, locations, or raw geology), or any other form of metadata, are available in the main report or any of its precursor open-file reports, hence little is known about the quality or basic description of the data upon which the interpretations presented on the maps are based. Roughly half of the data points clearly coincide, both spatially and in gross character (e.g., borehole depth, bedrock elevation) to wells shown by Johnston, but 29 others are “drillholes” of unknown origin and geology; possibly they are test holes drilled during the USGS mapping program or other “holes of fortune” available at that time but not documented. The lack of documentation and raw description reduces the utility of the data and creates some uncertainty in estimating their reliability, an issue heightened by the fact that, in some cases, Froelich’s interpretations of some of Johnston’s wells do not appear justified based on the well-construction characteristics presented by Johnston (1961). Nevertheless, the geologic data for all of Froelich’s points were taken at face value, *except* in several cases where a gross conflict exists between the interpretation shown by Froelich and the data presented or inferred from Johnston, or where Froelich’s interpretations are internally inconsistent. Most of these conflicts revolve around the depth to bedrock, or the thickness and/or percentage of sand of the Potomac Formation. For example, the well construction data presented by Johnston suggest that certain wells did not penetrate bedrock, so the reason(s) leading Froelich to assign an absolute bedrock altitude value to such points is unclear since they are not documented in any of the reports. The data from Froelich’s maps are compiled onto the page “Froelich 1985” in the database, which differentiates between wells also contained in Johnston (1961) versus the other 29 wells and boreholes whose derivation is not stated by Froelich.

Darton (1950): Darton compiled comprehensive data on the elevation and geology of the bedrock surface throughout the greater DC area, derived from detailed descriptions of hundreds of wells, tunnels, shafts, and excavations over many decades; using a variety of sites as examples, he compiled detailed maps of the topography of the bedrock surface in local areas, such as the Pentagon, as well as a more generalized bedrock topography map of the entire region at a scale of 1:31,680 (1 inch = one half mile). The raw information collected by Darton is

presented in a series of tables, accompanied by a plate showing the locations of wells and other data points on a detailed topographic base map. The large majority of Darton's data are from the District of Columbia and Maryland; although there are only a handful of wells within Alexandria, the information they provide is singularly important because they are concentrated around the south end of the Seminary terrace, where few other reliable bedrock data are available. Darton's data in that area reveal a tantalizing example of what appears to be a high-local-relief bedrock surface. Data for 30 of Darton's wells in and proximal to the city are presented in the page entitled "Darton 1950" in the database.

Subsurface Data-Geotechnical Borings: Geotechnical borings were obtained from the city for numerous building sites, schools, and other city-regulated construction activities, as well as from VDOT for two major roadways: Shirley Highway and the Capital Beltway. All of the boring sites can be precisely located and contain detailed information about elevation and the strata penetrated in the borings (usually described in terms of the engineering properties of soils). In nearly every case, a boring "site" identified in the database or on plate 1 includes more than one test boring; in fact, some of the larger sites have dozens or hundreds of borings. No attempt was made during this project to provide exact locations for individual borings; instead, the coordinates in the database represent a central location at each site. It is necessary to consult the individual boring plans to determine the precise number of borings at each site and their respective locations within the site. Every boring site (except for the Capital Beltway, see below) was tagged with a unique master ID number, which is how they are identified in the database entitled "Alexandria Geotechnical Borings" and on plate 1. Numbers 801 and higher were reserved for geotechnical boring sites; there are currently 111 such numbers (801-911) in the database, representing hundreds, if not thousands, of individual borings.

City of Alexandria Geotechnical Borings: Several departments review geotechnical borings in advance of various building projects. The boring records are typically submitted to the city as part of a geotechnical report in support of each project; the reports are filed in the plan review section of Transportation and Environmental Services (T&ES). In the case of city schools, they are filed in the school facilities office. Geotechnical reports and boring logs (paper copies) for some 75 sites were obtained and reviewed for this project. The number and depths of borings at a given site range widely, depending on the scope of the building project. Small projects typically consist of between 1-5 borings that range from 10 to 25 feet deep, whereas some major projects include dozens of borings that range up to 100 feet deep. To simplify interpretation at large sites, the borings were summarized into one or more site schematics or cross sections. At the time of this project, T&ES was in the process of sending out all of their archival project files to a private company for scanning, with the goal being to archive these older files electronically, mainly in PDF format. Therefore, files for a large number of past projects were unavailable at the time data were being compiled for the present project. It is anticipated that boring sets for dozens, and perhaps hundreds, of other sites within the city will become available over the next 1-2 years, in digital format.

VDOT-Shirley Highway: Numerous bridge borings were made at every interchange when Shirley Highway was expanded into a modern interstate (I-395) in the 1960's. The borings at each interchange are depicted on large-format bridge plans, which are archived on film at VDOT's northern Virginia office in Chantilly. For this project, full-size prints were made off of the film for all interchanges from Edsall Road northward to Glebe Road. As with the city boring

sets, each site was given a unique master ID number, and contains multiple borings, which are summarized on a schematic prepared during the course of this project.

VDOT-Capital Beltway: The replacement of Woodrow Wilson Bridge (WWB) and reconstruction of adjacent sections of the Capital Beltway is a major, long-term project that was still ongoing at the time of this study. Several hundred individual test borings have been made just for the section of the beltway in Alexandria between Route 1 and the city limits two miles west of Telegraph Road. Because the subsurface database for the WWB project is so vast, it is being handled differently by VDOT: all of the data are available at the VDOT website through a pilot project involving on-line GIS (see http://gis.virginiadot.org/GDBMS_menu.asp). Although it would have been possible to generate printouts (or digital files) of each individual boring, such a task would have been prohibitively time consuming. Instead, the site allows a remote user to generate “fence diagrams” (similar to geological cross sections) by selecting up to ten borings; the site then generates a cross section, or “fence”, with each boring in its proper spatial location and elevation range, and showing the strata and other engineering features of each boring. By reviewing the on-line borings on the VDOT site, a series of 14 fence diagrams were generated for this project, using the deepest and most descriptive geotechnical borings along the Beltway from Route 1 westward to the city limits. When placed end to end, the fence diagrams essentially act like a long geological cross section that follows the Beltway down Cameron Valley through the city. This approach saved a huge amount of time, and instead of having hundreds of boring sites, each of the 14 fence diagrams acts as a “site” for purposes of the database. The fence diagrams are included with this report as PDF files, and their locations are depicted on plate 1 by the violet-colored “swaths” along the beltway. The names of the fence diagrams are referenced to the Telegraph Road interchange: 1-west, 2-west, etc refer to fence diagrams located west of Telegraph Road; 1-east, 2-east, and so forth refer to those located east of the interchange. Two additional fence diagrams run north-south across the Cameron Valley, one paralleling Route 1, the other parallel to Telegraph Road, for a total of 16 such diagrams in the project database.

Other Data: The USGS collected a variety of regional geophysical data, much of which is unpublished. Regional aeromagnetic data, compiled at a 1:24,000 scale, were essential to the interpretation of bedrock geology and structure (e.g., faults) in the large majority of the city where the bedrock is buried beneath Coastal Plain deposits, and thus not visible. Daniels (1980) used the aeromagnetic data and several other kinds of geophysical information to make a similar interpretation of the bedrock geology for all of Fairfax County (including Arlington and Alexandria); his interpretations were extremely helpful and form the basis for the bedrock geology shown on plate 3. Published 1:24,000 geologic maps for the adjacent Washington West (Fleming and others, 1994), Annandale (Drake and Froelich, 1986), and Falls Church (Drake and Froelich, 1997) quadrangles were also extremely useful for constraining map units, contacts, and structures. In particular, the combination of the regional aeromagnetic data and the author’s familiarity with the Washington West Quadrangle enabled the bedrock structure to be extended southward into the coastal plain section of Alexandria with a reasonable amount of confidence.

Cross Sections

A series of 18 geologic cross sections (plates 2A-C) were constructed using various combinations of the data described above. Most of the cross sections broadly parallel major urban corridors such as King Street and Shirley Highway, and/or encompass significant

environmental sites, such as Rynex and Dora Kelley Natural Areas, Cameron Valley, and Chinquapin Hollow. The cross sections are oriented to either broadly parallel the regional dip of the bedrock surface and Potomac Formation, or to cut across it at nearly right angles. The cross sections can be thought of as vertical slices extending downward from the modern land surface to the maximum depth to which data are available, which is generally the bedrock surface in most of the city. They depict the vertical profile of rocks, sediments, and ground water levels encountered in wells, borings, and exposures in relation to the landscapes they occur with, and so represent the crucial third dimension needed for geologic and ground-water interpretations. The individual lines of cross section are depicted on plate 1 using a series of colors to distinguish one section line from another at places where they intersect on the map. As noted earlier, the cross section following the beltway consists of a series of fence diagrams generated entirely off of the VDOT WWB website using only VDOT borings; the rest of the cross sections include a broad mix of surface observations and subsurface data from a variety of sources.

References

Daniels, D.L., 1980. Geophysical-geological analysis of Fairfax County, VA: U.S. Geological Survey Open-File Report 80-1165, 64 pp.

Darton, N.H., 1950. Configuration of the bedrock surface of the District of Columbia and vicinity: U.S. Geological Survey Professional Paper 217. 42 pp plus 4 plates.

Drake, A.A., Jr., and Froelich, A.J., 1986. Geologic Map of the Annandale Quadrangle, Fairfax County, Virginia. U.S. Geological Survey Geologic Quadrangle Map GQ-1601. Scale 1:24,000.

Drake, A.A., Jr., and Froelich, A.J., 1997. Geologic Map of the Falls Church Quadrangle, Fairfax and Arlington Counties and the City of Falls Church, Virginia. U.S. Geological Survey Geologic Quadrangle Map GQ-1734. Scale 1:24,000.

Fleming, A.H., Drake, A.A., Jr., and McCartan, Lucy, 1994. Geologic Map of the Washington West Quadrangle, District of Columbia, Montgomery County, Maryland, and Arlington County, Virginia. U.S. Geological Survey Geologic Quadrangle Map GQ-1748. Scale 1:24,000.

Froelich, A.J., 1985. Folio of geologic and hydrologic maps for land-use planning in the Coastal Plain of Fairfax County, Virginia, and vicinity. U.S. Geological Survey Miscellaneous Investigations Series Map (IMAP) I-1423. Scale 1:100,000.

Johnston, P.M., 1961. Geology and ground-water resources of Washington, D.C. and vicinity: well records and data tables. U.S. Geological Survey Open-File Report 61-79.

Johnston, P.M., 1964. Geology and ground-water resources of Washington, D.C. and vicinity. U.S. Geological Survey Water Supply Paper 1776. 98 p. scale 1:62,500